Experimental method for the state of charge determination of TABS

Bram van der Heijde, Edorta Carrascal Lecumberri, Lieve Helsen

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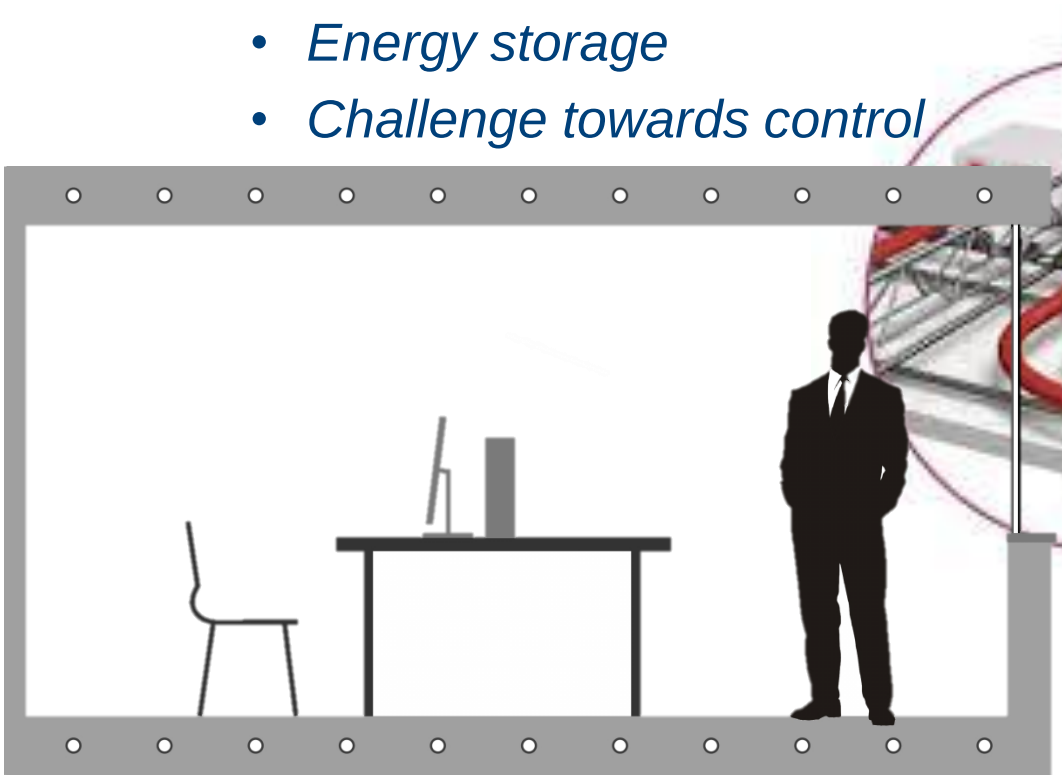
Thermally activated building systems

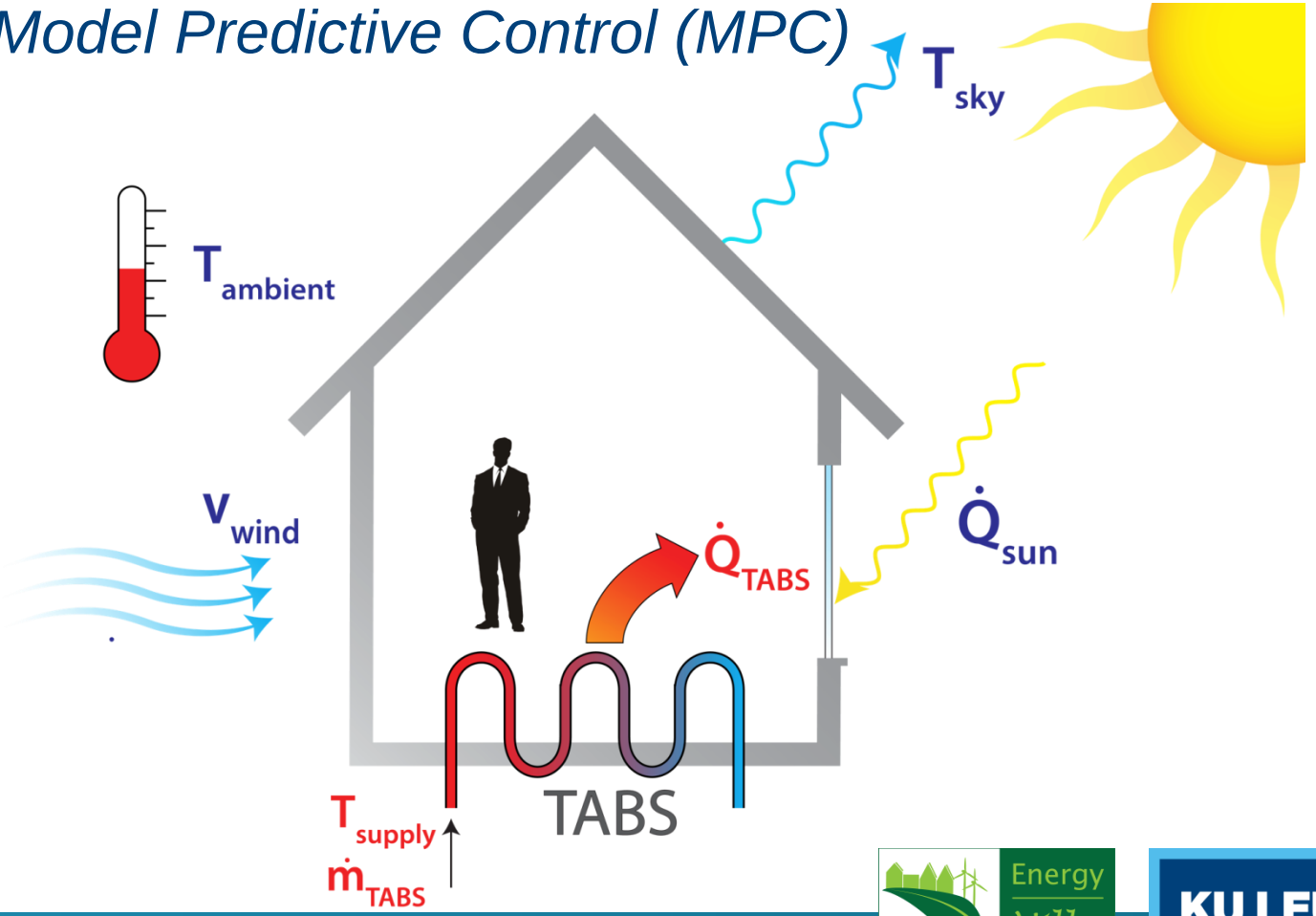
- Heating/cooling with floor as emitting system
  - *Concrete core activation*
- High thermal mass
  - *Energy storage*
  - *Challenge towards control*



Source: http://www.specifile.co.za/images/news/2012/march-2012/images/large/Rehau Thermally-Activated-Building-Structure.jpg

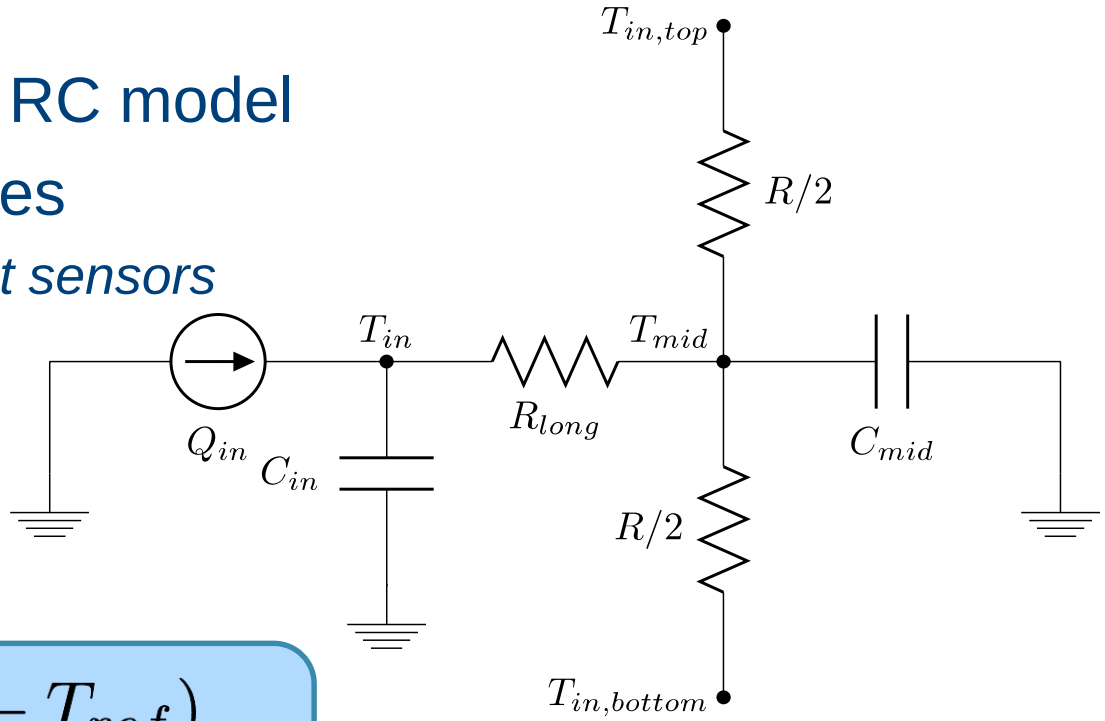
Why state of charge (***SoC***)?

- Input parameter for efficient control
  - ➔*Model Predictive Control (MPC)*



SoC indicator

- Represent floor with RC model
- Simulate temperatures
  - *Minimal set of input sensors*

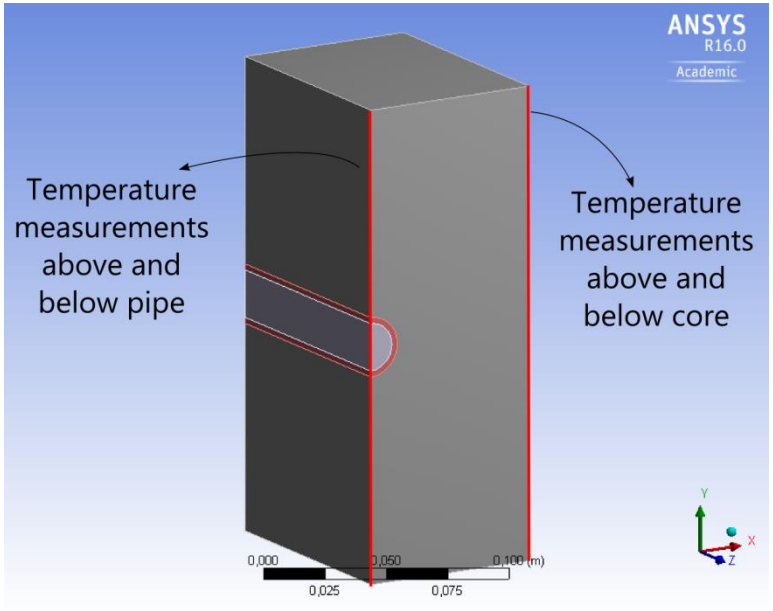


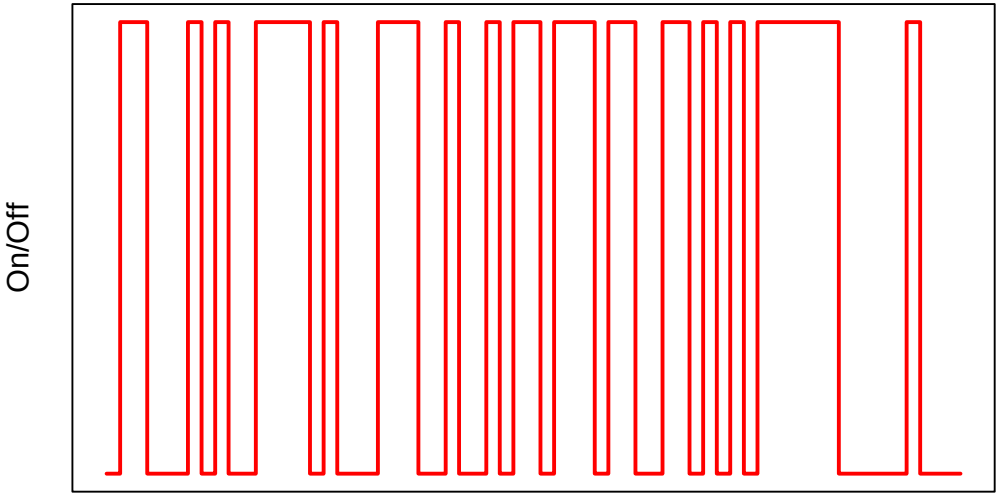
$$\mathrm{SoC} = \frac{\sum_i C_i (T_i - T_{ref})}{\sum_i C_i (T_{max} - T_{ref})}$$

- T_{max} and T_{ref}?

Experiment design

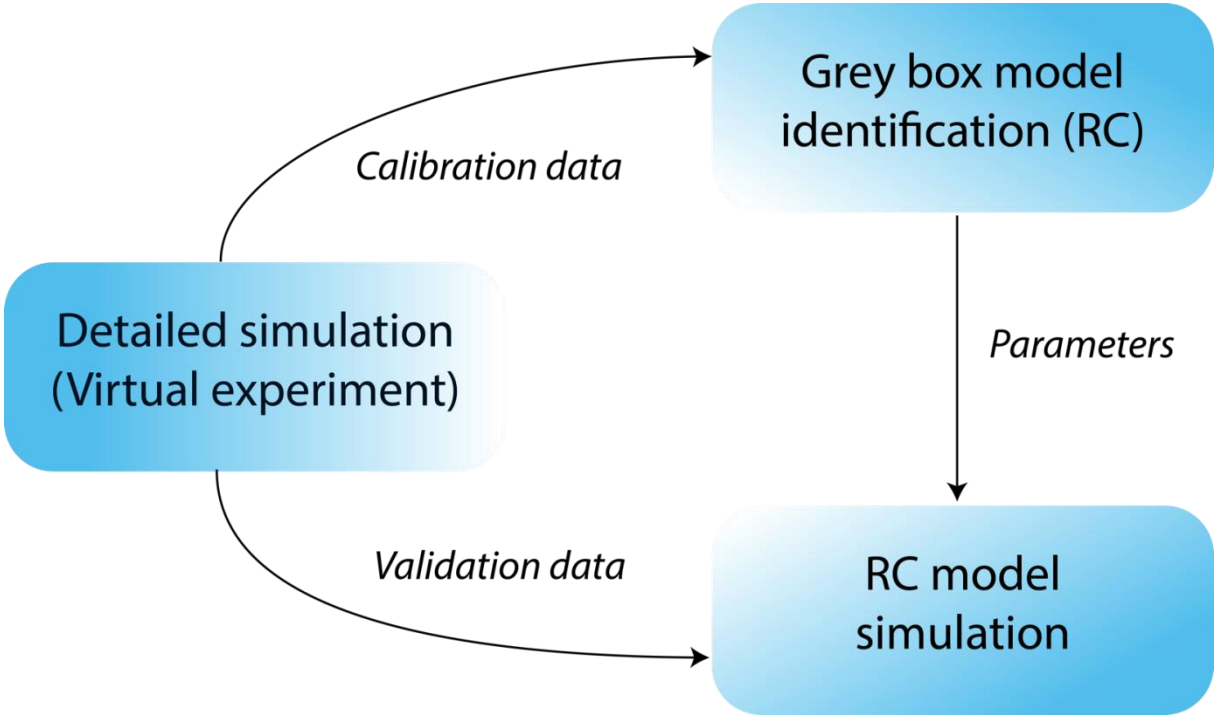
- Up to now: virtual experiments (simulation)
- Solid concrete floor with pipes in the middle
- Heating/Cooling switched using PRBS
  - T_{supply} and *mass flow rate* fixed
- Measure temperatures and energy





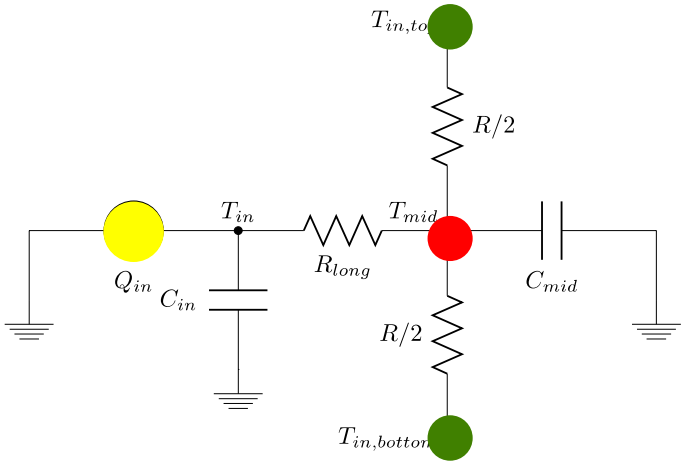
RC model identification

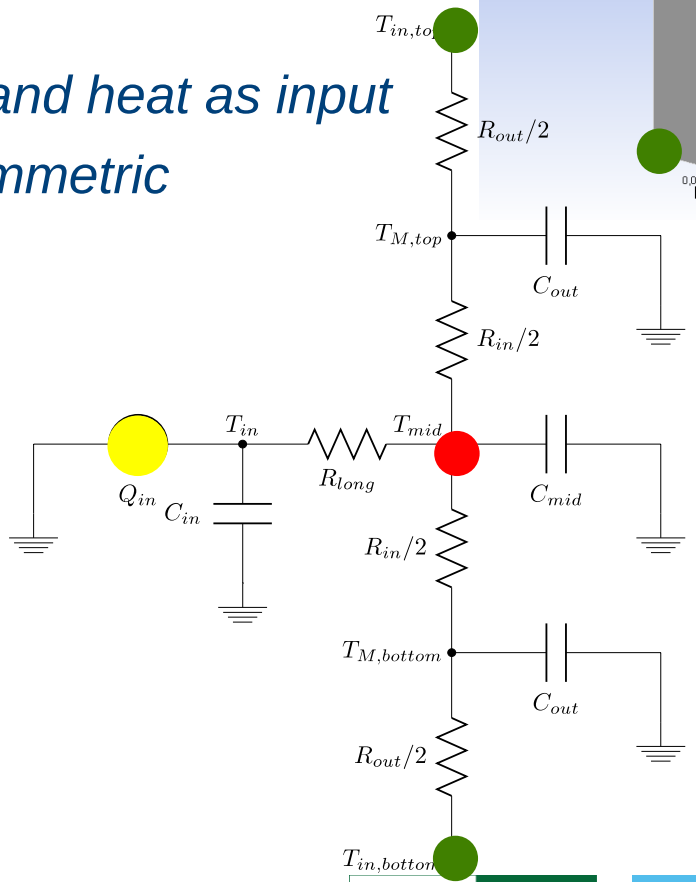
- Estimate parameters with GreyBox Toolbox (De Coninck et al., 2015)

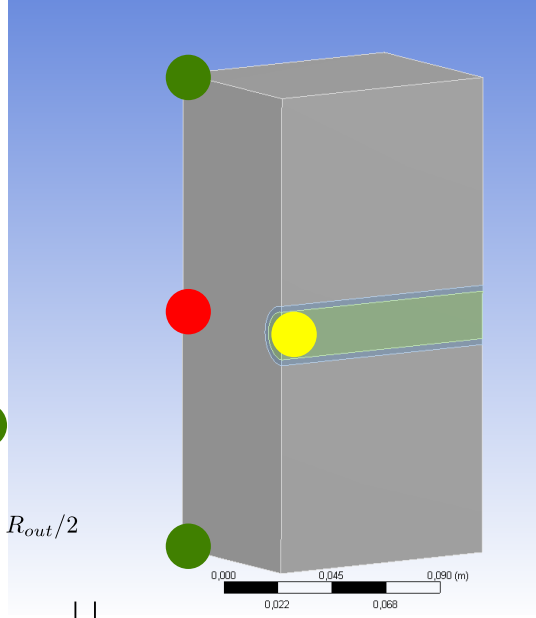


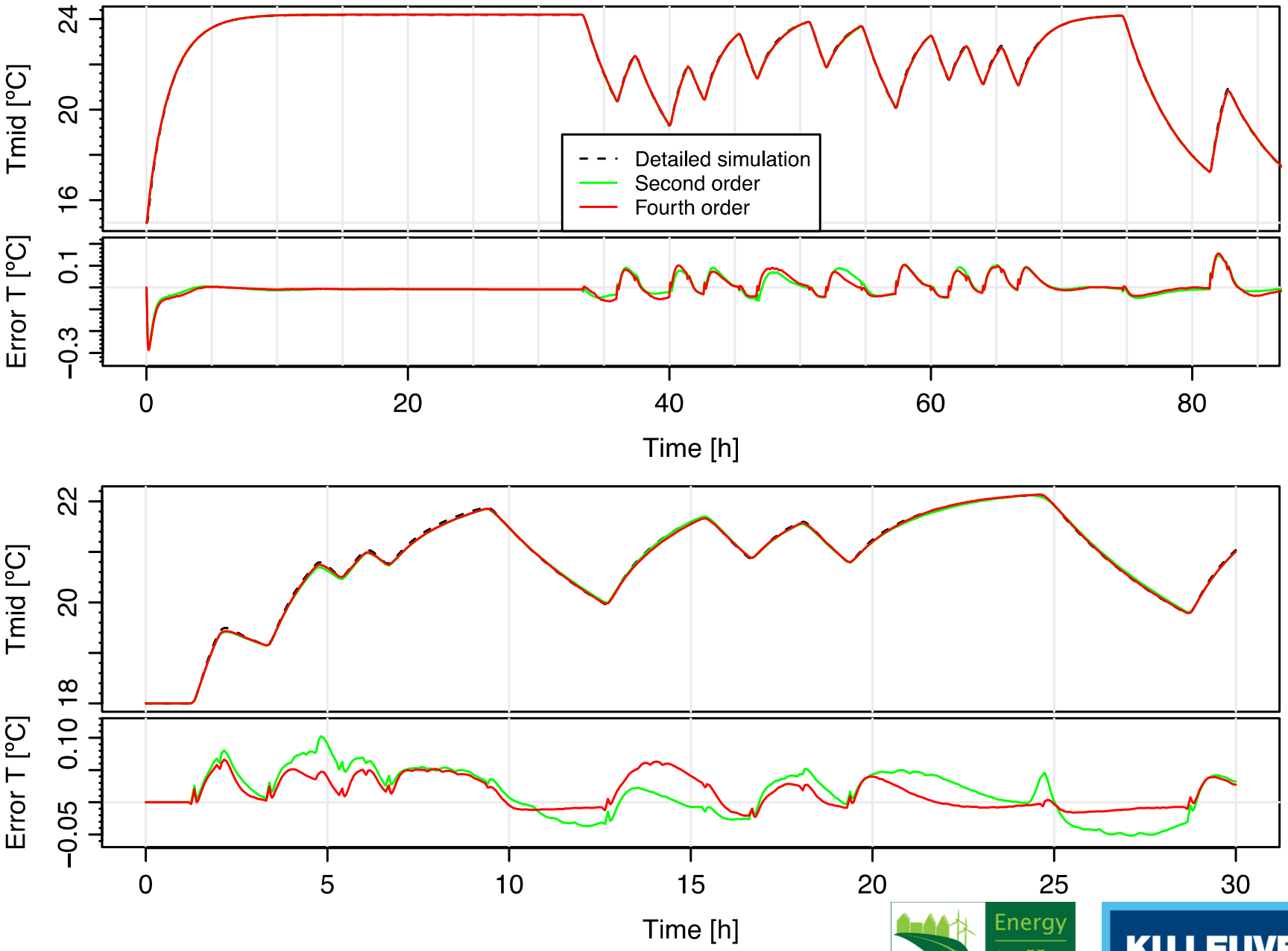
RC model identification

- Best result:
  - *Predict core temperature*
  - *Top & bottom temperature and heat as input*
  - *2nd and 4th order model, symmetric*

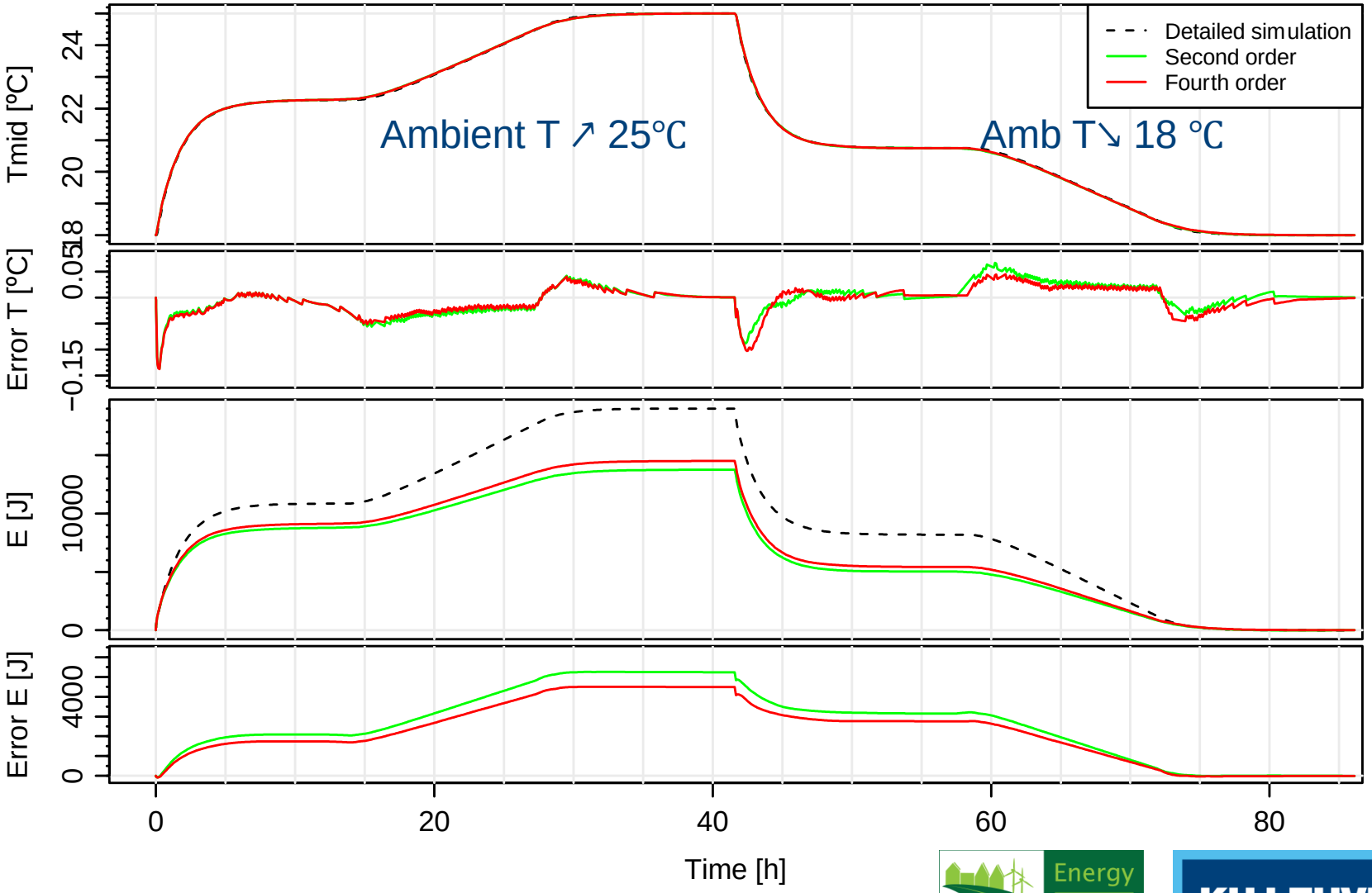




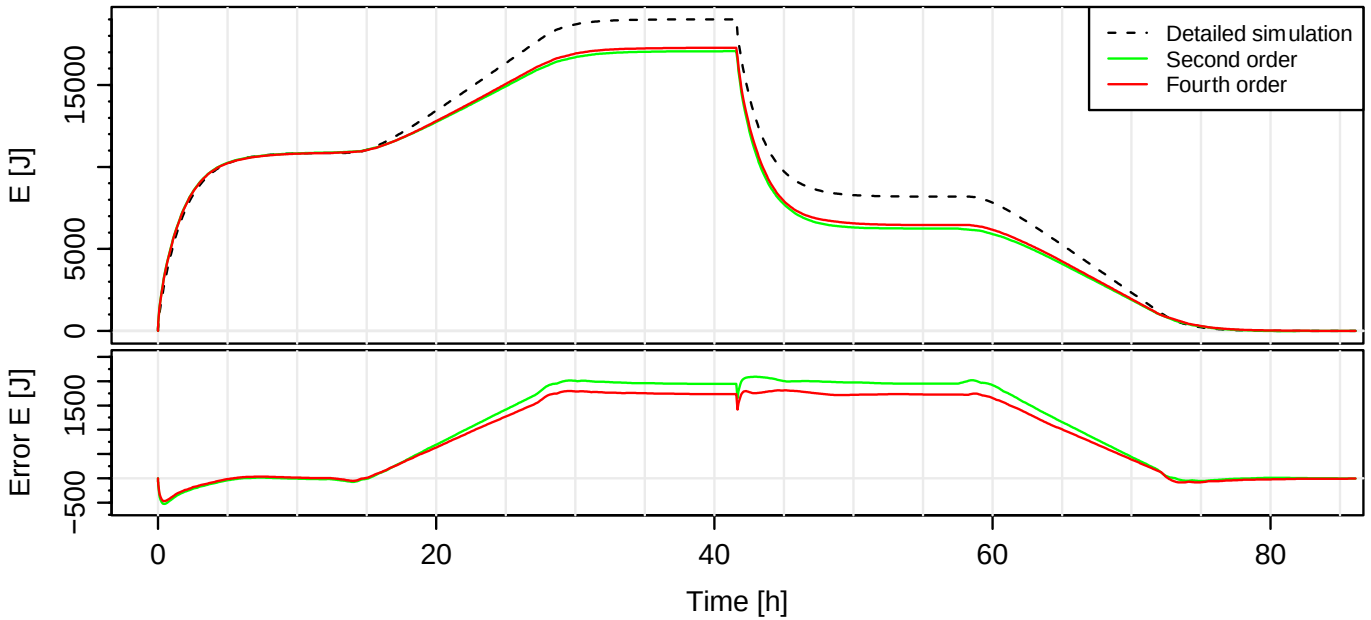



Tmid [°C]
24
20
16
Detailed simulation
Second order
Fourth order
Error T [°C]
0.1
−0.3
0
20
40
60
80
Time [h]
Tmid [°C]
22
20
18
Error T [°C]
0.10
−0.05
0
5
10
15
20
25
30
Time [h]

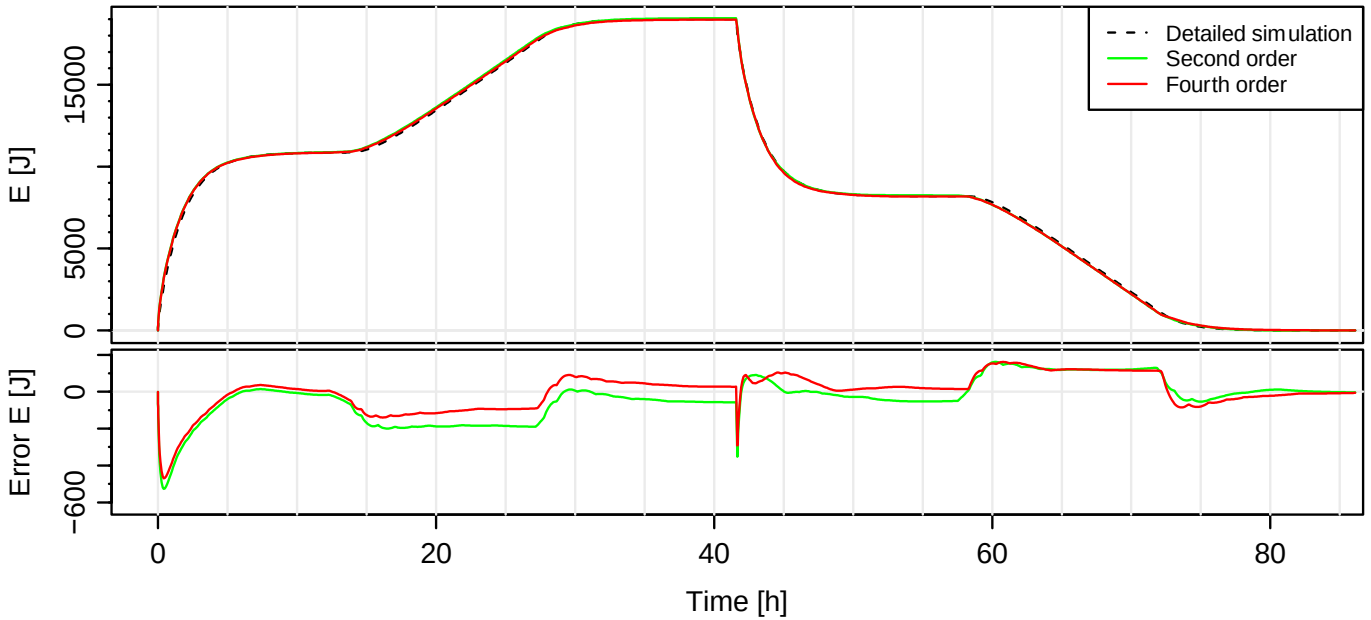
Model corrections



$$\beta \cdot E$$

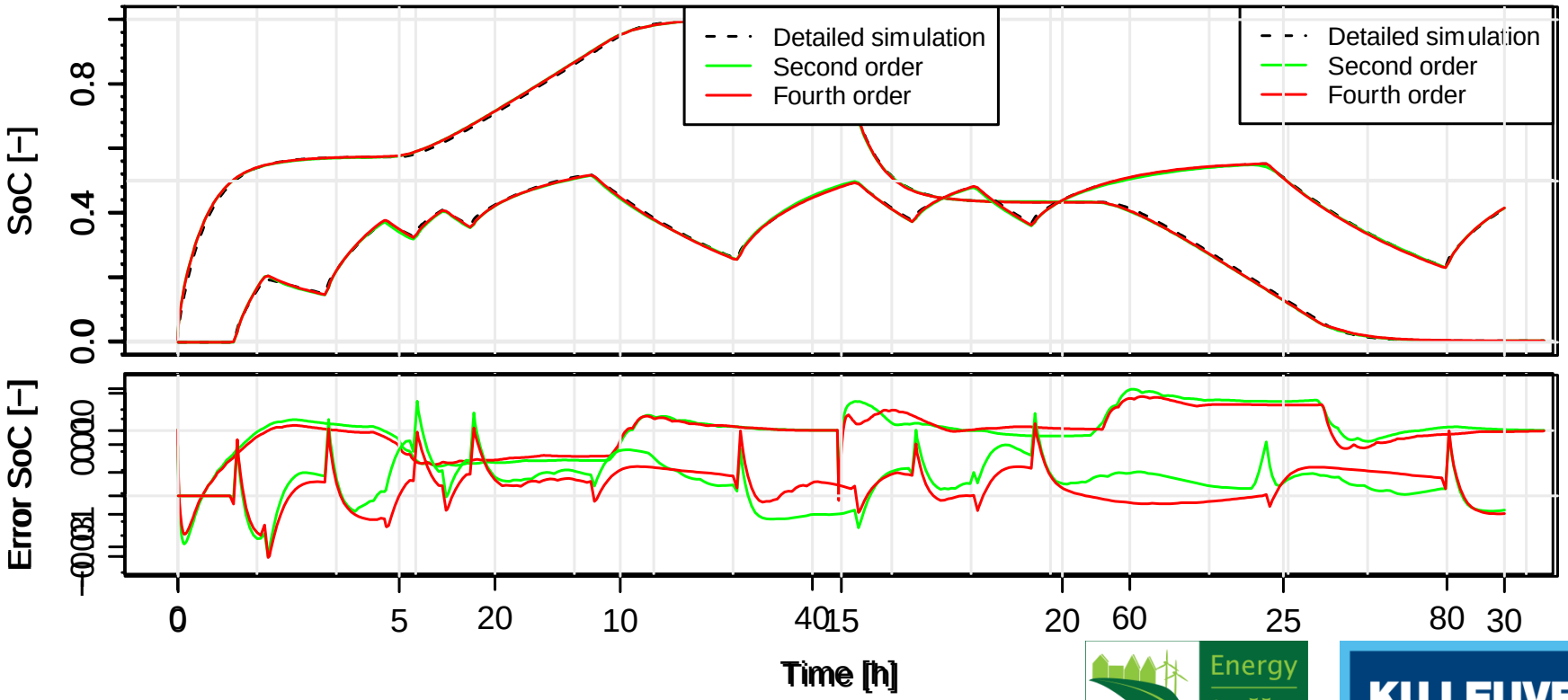


$$+C_{amb} \cdot \Delta T_{amb}$$



State of charge

$$\mathrm{SoC} = \frac{\sum_i \beta C_i (T_i - T_{ref}) + C_{amb}(T_{amb} - T_{ref})}{\sum_i \beta C_i (T_{max} - T_{ref}) + C_{amb}(T_{max} - T_{ref})}$$

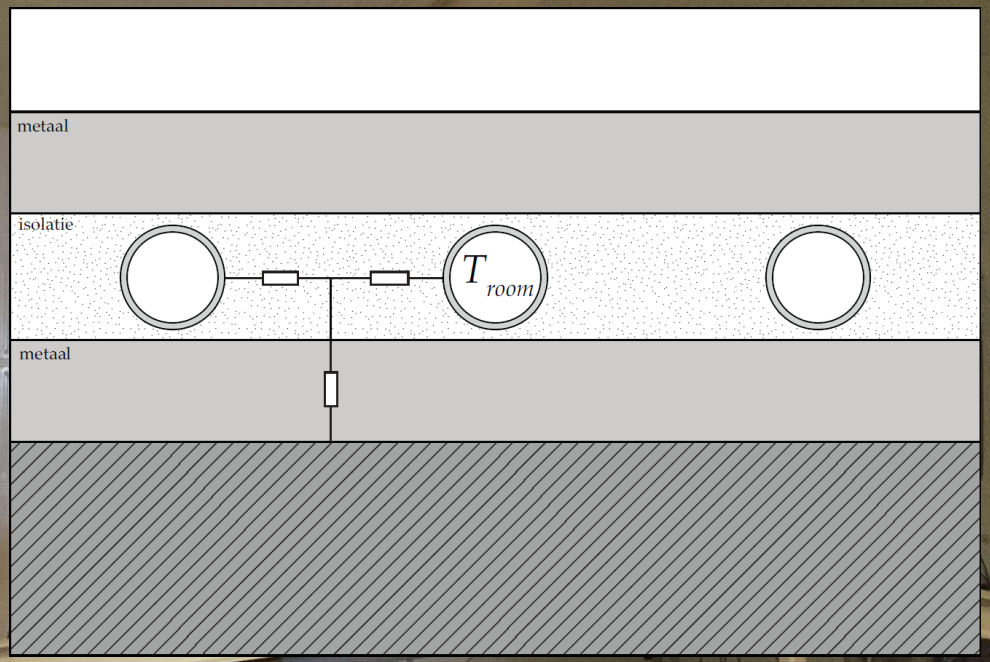


Conclusions

- Successful indicator for SoC after corrections
- Results valid for multiple types of operation
- Only 3 input measurements needed

Further work

- Increase floor complexity
- Real experimental data
- Include realistic disturbances


metaal
isolatie
T_{room}
metaal